COUNTDOWN ACID RAIN

Ontario Environment
Environnement

ACIDIFICATION – WARNING SIGNS

Throughout Ontario and much of Eastern Canada, thousands of lakes are struggling to survive the effects of acid rain, and many are losing the battle. Some have already acidified and others are reaching a critical state. In limestone terrain the lakes maintain their equilibrium through the protective chemistry of the surrounding rocks and soils. In the long term, lakes in these resilient areas will be able to withstand continuing acid precipitation. In the vast Canadian Shield region, however, the terrain offers its lakes no alkaline buffering, leaving them vulnerable to death by acid rain.

How Does a Lake Decline?

The speed at which a lake acidifies is largely determined by its natural chemistry and its geography – the exposure of the area to acid deposition, and the individual characteristics and sensitivity of the local geology and vegetation.

Each lake supports a unique ecosystem, but fundamentally, the process of acidity-caused degeneration is the same for them all. One by one, organisms in the aquatic food web succumb to the effects of increasing acidity. As the system breaks down, it loses its ability to support diverse life forms. Eventually it becomes unable to sustain anything other than a few highly resistant species, such as slimy algae.

This has already happened to some of our lakes and will become a reality for many more unless strong measures are taken to protect them soon. In Ontario, the Peterson government has introduced a program called *Countdown Acid Rain*, which is making major reductions in the province's sulphur dioxide emissions. However, U.S. sources are responsible for 50% of the acid rain that falls in Ontario and without the implementation of abatement measures by our neighbours south of the border, our acid sensitive lakes have little chance of survival.

Post Mortem

Scientists have not monitored the effects of acid rain long enough to be able to predict exactly when a lake will acidify. However, numerous studies have been carried out in recent years and some conclusive evidence has emerged. We now have a fairly clear picture of what happens to a lake as it declines.

It is not a pretty picture. If we do not succeed in controlling acid rain, the history of many more of our lakes might read as follows:

Take an average lake of about 100 hectares, with a corresponding watershed of about ten times this area. It is surrounded by a pine and maple forest. The bedrock is typical Canadian Shield granite and the soil a thin organic layer on sand or gravel. The water is roughly 30 meters in depth and at the beginning of this "history" had a pH of 6.8.*

A number of years ago, the lake supported thriving plant and animal communities. There were plenty of fish – lake trout, yellow perch, white suckers and a variety of forage fish, such as common shiners and lake chub. Crayfish, clams and snails crawled on the lake bottom, water beetles scooted across the surface and dragonflies and mayflies hovered above it. Frogs crouched on lily pads waiting for unwary insects, snakes slithered in the mud and turtles sunned themselves on the rocks around the shore.

The aquatic creatures provided a rich diet for many birds. Kingfishers and a pair of loons nested on the lake and blue herons were seen from time to time. Various mammals, such as a family of mink, made their homes along the shoreline and beavers had built a large dam on the outlet stream. Moose came to feed on the waterlilies and otters visited occasionally to hunt for fish.

As North American industrialization grew, the environment around the lake received increasing punishment from acid rain. Upwind, nickel and copper smelters and several coal-fired generating stations were spewing tons of sulphur dioxide into the air every year. Growing cities jammed with cars, trucks and buses added a smog of nitrous oxides. Small industries contributed their smoke, and prevailing winds carried this pollution over the lakes and forests. In the atmosphere the emissions were transformed into acid, bringing the pH of the precipitation down until it was rarely higher than 4.2.

For a while the natural alkalinity of the lake and its surrounding soils counteracted

pH Greater than 5.0

the acid rain, but the granite bedrock contained very little of the calcium carbonate needed to neutralize the increasing acidity. Within a few years the normal slight rise and fall in the pH of the lake had begun to tilt to greater and greater extremes of acidity. The sudden thawing of acid snow in the spring could bring the pH of the surface waters plunging to 4.0, and throughout the year any unusually heavy rain could create a similar pulse of acidity.

It is not long before the lake's inhabitants began to suffer from the effects of these acid shocks. One spring the eggs of leopard frogs spawning in pools of meltwater failed to hatch, and in the inlet streams a new generation of white suckers died as soon as they emerged as fry.

In the next spring melt, the young of the johnny darter were lost too. The lake was unable to recover fully from the constant acid loading of heavy rains during the summer, and its overall pH began to decrease.

When the lake pH reached 5.6 the opossum shrimp were gone and their predators, young lake trout, were becoming emaciated.

During the next few years the changing chemistry of the water affected not only vulnerable eggs and fry, but also the adult aquatic creatures. Aluminum, leached from the soil by acid run-off, was reaching poisonous levels in the lake. Stressed by this and the low pH, many of the lake's inhabitants failed to reproduce.

Because of the water's acidity the crayfish found it difficult to harden their exoskeletons.

simply decreased at a steady rate. There were no birds, no fish, no amphibians and no mammals.

Before long, the lake had reached a pH of 4.3, almost as low as the acidity of the precipitation itself. It still looked beautiful, but the healthy blue-green clarity of the water belied the fact that most of its inhabitants had gone. Only a few undesirable life forms suited to acid conditions remained. A complex and abundant ecosystem had become an acid reservoir. The lake was finished.

Warning Signs

The above "history" is compiled from data from a broad range of lake studies. There is no shortage of real life examples to warn that, while our lakes may be degenerating at different rates, they are all heading in the same direction.

Algae

As lakes acidify the diversity of species declines. Giant balls of slimy filamentous algae, *Mougeotia*, *Zygogonium*, and *Zygnema*, which thrive in acid conditions, appear more frequently as other species dies out. The marked change in community composition has a corresponding effect on the food chain.

Other undesirable species are favored by low pH. Experiments on the alga *Chrysochromulina breviturrita* show that blooms will occur creating noxious lakewide odours, even in moderately acid lakes.

Crustaceans

Opossum shrimp (*Mysis relicta*) become extinct at about pH 5.8. Amphipods (*Hyalella azteca*) are seldom observed below pH 5.6.

Three common species of crayfish *Orconectes virilis, O. propinquus* and *O. rusticus* are extremely sensitive to acidity. Testing showed that they developed a variety of stresses below pH 5.7. Calcium uptake was inhibited, delaying hardening of the exoskeleton. Parasitism became a problem, egg mortality increased and many of the young failed to mature.

Molluscs

In acid conditions, the common and usually abundant snail *Amnicola limnosa* displayed a significant decrease in growth and became scarce. In Heeney Lake total developmental failure occurred at pH 5.0 and apparent reproductive failure was also observed.

Insects

Data suggest that a number of genera of mayflies and stoneflies are sensitive to low pH. Their eggs are laid and hatch in the water, and under acid conditions few young will survive beyond the larva stage.

Amphibians

Although terrestrial as adults, amphibians are aquatic creatures at the earliest and most vulnerable stages of their lives, so the most direct impact of acidity is on their eggs and larvae. Since many amphibians spawn in pools of meltwater, the spring acid shock will often wipe out these species long before the lake itself reaches a low pH. Some species, such as the bullfrog (*Bufo americanus*) will suffer 100% mortality of eggs at pH 4.1 and others such as the spotted salamander (*Ambystoma maculatum*) showed a 65% loss of embryos in ponds with a pH of 5.0.

Fish

During the 1960s, in the lakes of the La Cloche Mountain region of Ontario, a variety of fish species disappeared. Species such as trout, bass and shiners died out very quickly as the lakes acidified, while hardier fish such as yellow perch and lake chub survived longer.

Fish populations disappear when reproductive failure occurs for a number of successive years. Either the eggs fail to hatch, or the vulnerable fry die as soon as they emerge. Few fish can reproduce at pH values below 5.0.

The loss of fry also removes a valuable food source from the ecosystem, which affects a variety of predators, including other fish.

Some fish develop skeletal deformities in acid conditions. Scientists hypothesize that this is because the acid water forces them to draw calcium from their own bones in an attempt to maintain nomal blood chemistry.

Wildlife

A vast number of birds and small mammals are dependent upon aquatic food sources, so when a species disappears an entire food chain is disrupted.

Elevated levels of mercury, cadmium and lead are suspected in acidifying lakes and may, therefore be present in the flesh of molluscs, crustaceans and the fish and birds that feed on them. Scientists are exploring the possibility that acidification also increases aquatic creatures' uptake of metals.

These highly toxic metals accumulate as they are passed up food chains. Combined with the low pH, this can have a severe effect on many species.

Hope for Recovery?

If acid deposition rates are reduced, there is evidence that lakes can recover from acidification – up to a point. On a local scale, in the Sudbury area of northern Ontario, (where smelters had long been one of North America's major point sources of pollution), recent reductions in industrial emissions have made a noticeable difference. Lakes in close proximity to the smelters were seriously acidified, but since about 1980 there have been substantial signs of improvement.

In some lakes the pH has risen by as much as 1.5 units, phytoplankton and insects have returned and fish that had ceased to breed are once more producing young.

Other lakes are too far gone in that the fish populations and other inhabitants such as crayfish and molluscs have died out completely. The aquatic creatures that can move from one lake to another may return eventually, but the natural recovery of the most seriously affected lakes will only be partial.

The recovery can be assisted artificially, for example by restocking the lake with individual species; but in reality there is only so much that can be done to recreate such a complex and carefully balanced system.

Many large food chains originate within the aquatic level of the ecosystem and the loss of life in the essential area cannot fail to have a major impact on the environment as a whole.

The Broader Hope

Current acid loadings across eastern North America are too heavy for many lakes in Ontario's Muskoka and Haliburton regions, New York's Adirondacks and other vulnerable areas. The remedy for acid rain damage is the extensive and methodical pollution control program set out in Ontario's Countdown on Acid Rain matched by equally strong cutbacks in other provinces and the United States.

Of course the aquatic element is only one of the aspects of the environment that is suffering from the effects of acid rain. For our environment – and for most of our lakes – it is not too late to do something to stop the damage and allow recovery, but action is needed, and it is needed now.

---

* A pH scale measures the acidity or alkalinity of a solution. It ranges from 0 to 14, and a pH of 7 is neutral. The lower the pH the greater the acidity. Because the pH scale is logarithmic, a decrease of one pH unit means a ten-fold increase in acidity. Normal "clean" rain is naturally slightly acidic with a pH of 5.6.

PRINTED ON
RECYCLED PAPER
IMPRIMÉ SUR
DU PAPIER RECYCLÉ

(version française disponible)

10K-03/91
649E

They became more vulnerable to parasites and the females ceased to be able to carry their eggs protectively, leaving them to be eaten by the remaining fish.

While the falling pH was taking its toll on the animal population, several unpleasant species of plant life had begun to proliferate. Slimy algal "blooms" appeared in the water with increasing frequency and another variety of algae gave the lake a garbage dump odour.

One year a rapid spring melt produced an acid shock that brought the pH of the lake down to 5.3 and several species of fish, such as the common shiner, disappeared completely.

Other species, such as the lake trout and burbot, had failed to reproduce for several years, so the remaining fish population consisted largely of older generations.

Within a few years there were no frogs in the lake. When the pH dropped below 5.5 the birds, accustomed to finding plenty of snails in the shallows, discovered that this food source was scarce too.

When the overall pH of the lake dropped below 5.0, the only fish left were acid resistant species such as yellow perch and lake chub. All of the crayfish and clams had gone, closely followed by the mayflies and dragonflies.

The loons, the mink and many birds, faced with starvation, moved on in search of lakes that could still maintain a food supply for them.

Eventually, the alkalinity of the entire watershed was exhausted and when the lake's pH fell to about 4.7, it ceased to fluctuate so wildly and